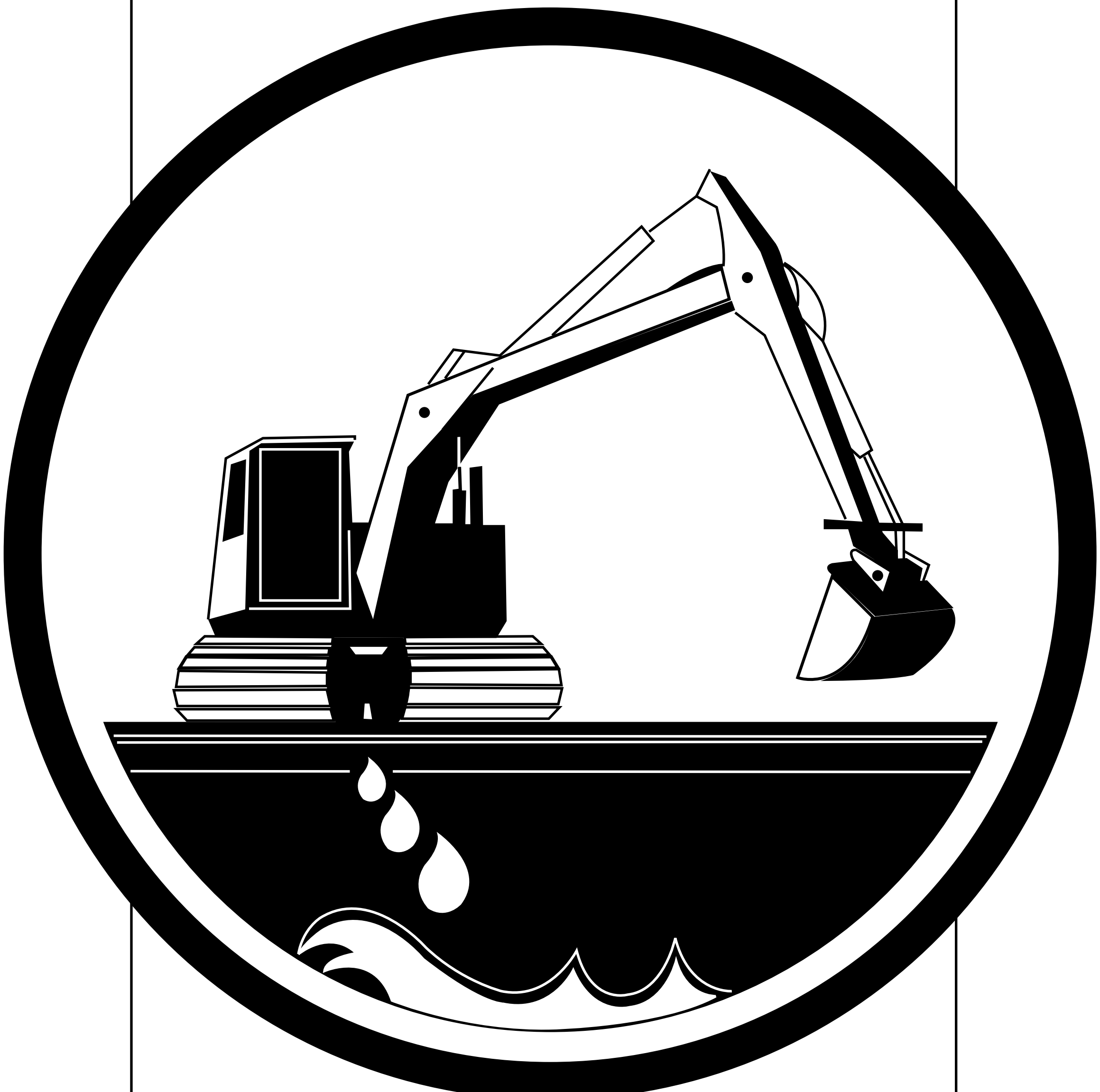
Iowa Construction Site Erosion Control Manual



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Iowa Department of Natural Resources

DISCLAIMER

This document is issued in support of federal, state, and local regulations and policies involving storm water runoff and soil erosion legislation. This document is for guidance only. Agency decisions in any case will be made by applying the laws and regulations on the basis of specific facts when permits are issued or regulations promulgated. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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PREFACE

The purpose of this Iowa manual is to serve as a guide, provide solutions, and offer suggestions on construction sites to comply with Iowa's current soil erosion and storm water runoff regulations. This need is particularly important when land undergoes a land use change. Information provided in this manual will be helpful to land owners, developers, consultants, contractors, planners, local government, as well as the general public.

This manual is intended to provide techniques that will meet the mandates of current legislation. Innovations that will benefit the user and still provide effective control are encouraged.

As an undeveloped area is changed to urban, commercial, or industrial use, natural cover is removed and the chance of erosion problems increases. Natural drainage areas are usually changed to remove runoff rapidly. In addition, paved streets, sidewalks, buildings, and compacted soil add to the runoff. Runoff from snow or rain in these developed areas often washes pollutants off the land and surface areas. These contaminates often contain salt, fertilizer, heavy metals, organic chemicals, pet waste, and sediment from construction sites.

Controlling erosion and water quality and developing procedures to manage construction sites to reduce off-site water pollution is a major concern. The Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation; the United States Department of Agriculture, Natural Resources Conservation Service; and the Iowa Department of Natural Resources, Environmental Protection Division are all agencies concerned with erosion and sedimentation problems that are present today. These agencies are engaged in technical programs that will reduce erosion and save our soil.

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Raccoon River Watershed Project
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Royal Environmental Systems, Inc.
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Scott County
Shive-Hattery Engineers
Sierra Club, Central Iowa Chapter
SI Geosolutions
Silt-Saver, Inc.
Snyder & Associates
Soil Conservation Service
Soil and Water Conservation Society
Soil-tek
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CHAPTER 1. INTRODUCTION

1.1 EROSION CONTROL

The purpose of this manual is to serve as a guide for reducing erosion and preventing sediment from leaving construction sites. In addition, this manual will provide information to contractors, developers, consultants, and planners to help guide them in (1) selecting erosion control practices and (2) preparing plans to reduce erosion on construction sites. Use of this manual is not limited to sites that require a National Pollution Discharge Elimination System (NPDES) permit for storm water discharge. This manual also contains information that a builder can use for building an individual house on a site as well as erosion and sediment control plan recommendations for larger tracts, even if an NPDES permit is not required.

In general, soil erosion is the removal of soil by water, wind, ice, and gravity. This manual deals primarily with soil erosion caused by raindrops. Raindrops strike the soil at a speed of approximately 25-30 feet per second. The impact of the raindrop causes particles of soil to be detached and splash into the air. After the soil particles become dislodged, they can be carried by surface runoff. Surface runoff begins when the soil is saturated and cannot absorb the falling rain. Scouring of the exposed soil by runoff can cause more erosion. As the runoff increases, it tends to be concentrated into rivulets and then into grass channels. As the speed of runoff increases, more soil particles are transported.

The dropping of sediment occurs when the surface flow lessens and the soil particles start to drop. The heavier particles such as gravel and sand settle first, and then the lighter particles settle. Little by little, silt and clay can be transported by rain and finally be carried downstream from its upland point of origin.

Rainfall on unprotected soil causes serious erosion and results in sediment being deposited in waterways and a general degradation of the environment. Public criticism can be very strong when streams are dirty, drainage areas clogged, water supplies threatened, and unsightly deposits of silt occur on the landscape. Certainly, the floods of 1993 demonstrated the power of water and its ability to move silt in staggering volumes.

Removal of soil by water at construction sites that are not protected can result in rills, gullies, sheet erosion, damaged slopes, eroded ditches, plugged drainage structures and culverts, and flooded work areas. Stream channels can be filled with sediment to the point where the flow elevation is raised enough to flood areas adjacent to the stream.

Sediment always damages the areas where it is deposited. For example, sediment buries crops and lawns, kills trees, and fills ditches and other drainage systems. Sediment reduces the storage capacity of reservoirs and fills small ponds and lakes. It also damages aquatic life. Sediment can render an area inadequate for its intended use. Sediment that reaches navigable waterways, such as the Mississippi River, requires the navigation channels to be cleared on a continuous basis.

The information contained in this manual will enable the reader to understand how erosion begins and how various factors affect erosion and sedimentation. This knowledge will then enable the user to apply the best management practices to control erosion and sedimentation.

Erosion and sedimentation are natural processes accelerated by human activities. This manual will therefore provide the user with information to minimize erosion and sediment problems on land undergoing construction activities. Control methods will show how to use plants, water, and soil to improve the quality of the environment.

Erosion Process

The erosion process is influenced by soil erodibility, climate, vegetative cover, topography, and season. Figure 1.1 illustrates the erosion process.

Figure 1.1. Erosion process (Source: photogallery.nrcs.usda.gov)

Soil Erodibility

The soil type determines how vulnerable the soil is to erosion, or its erodibility. Properties determining how easily a soil erodes are texture, structure, organic matter content, and permeability. The most erodible soils generally contain a high percentage of fine sand and silt. The presence of clay or organic material tends to decrease soil erodibility. Clays are sticky and tend to bind soil particles together and resist erosion. But while clays resist erosion, they are easily transported once they have eroded. Well-graded and well-drained gravels are usually the least erodible soils.

Climate

Rainfall characteristics such as frequency, intensity, and duration directly influence the amount of runoff that occurs. As the frequency of rainfall increases, water has a reduced chance to drain through the soil between storms. When the water cannot drain, the soil will remain saturated for longer periods of time and the volume of storm water runoff may be greater. Erosion risks are high where rainfall is frequent, intense, or lengthy.

Vegetative Cover

Vegetative cover is an extremely important factor in reducing erosion from a construction site. Vegetation protects soil from the forces of raindrop impact and runoff scour. While the top growth shields the soil surface from the raindrop impact, the root mass holds the soil particles in place. Grass buffer strips can be used to filter sediment from surface runoff. Grasses also slow the speed of runoff and help maintain the infiltration capacity of the soil. Establishing and maintaining vegetation can be an effective means for minimizing erosion during development.

Topography

Slope length and steepness influence both the volume and velocity of surface runoff. Long slopes produce more runoff to the bottom of slopes. Steep slopes increase runoff velocity. Both situations increase the potential for erosion.

Season

Temperature has a significant influence on soil erosion. Seasonal variation in temperature and rainfall changes the erosion potential during the year. Frozen soils are relatively erosion-resistant. However, a high erosion potential may exist in the spring when the surface soils first thaw and the ground underneath remains frozen. A low-intensity rain at that time may cause serious erosion because the frozen subsoil prevents water infiltration. Erosion increases during the summer months because of more frequent, intense rains.

Types of Erosion

To deal with water erosion problems effectively, five major types of erosion and their characteristics must be understood so that appropriate control measures can be selected.

Raindrop (Splash) Erosion

When the vegetative cover is destroyed, the soil becomes directly exposed to the impact of raindrops. The soil particles are separated as raindrops strike the bare soil.

The pounding action of the rain destroys the soil structure. As the soil dries, a hard crust often forms. This crust slows plant establishment and reduces water infiltration, thereby increasing future runoff and erosion. Raindrop erosion is related to rain intensity and raindrop size. Some splashed particles may rise as high as 30 inches and move as much as 60 inches horizontally. On a slope, the particles will move down the slope because of gravity.

Sheet Erosion

Erosion caused by water flowing over the soil surface is referred to as sheet erosion. The shallow, moving sheets of water are not usually detaching agents, but the flow of water transports soil particles that have become detached by raindrop impact. The shallow water usually moves as a uniform sheet for only a few feet before concentrating in low spots and other uneven spaces.

Rill Erosion

Rill erosion begins when the shallow sheet flow begins to concentrate in the low areas of the soil surface. When the flow begins to change from sheet flow to a deeper flow in the low areas, the turbulence and velocity of the water increases. This deeper flow now has the energy both to detach and transport soil particles. The small channels cut into the soil surface by this action are called rills. For the most part, rills are only a few inches deep, but are well-defined channels.

The Alutin Rill Erosion Method is a rapid method of measuring rill erosion that is fairly accurate for losses up to 100 tons per acre. The formula for this method is as follows:

The soil loss in tons per acre is equal to the sum in square inches of the cross-sections of rills along a measured lineal distance of 13.7 ft (14 ft) across the slope. For greater accuracy, a 42 ft or 84 ft measurement across the slope can be used, and the sum of the rill measurements can be divided by 3 for 42 ft and 6 for 84 ft.

Gully Erosion

Gullies are formed when runoff cuts rills deeper than ordinary tillage can eliminate. Gullies can become enlarged both up and down the slope. In some soils, a heavy rain can change a rill into a major gully in a very short time. Gullies are difficult to stabilize and costly to control. Erosion loss can be measured by the cross-section method before and after a storm.

Channel Erosion

Channel erosion occurs when the velocity of the flow in a stream is increased or when the bank vegetation is damaged or destroyed. This type of erosion is most common at bends in the stream or where the flow is restricted. Damage may also occur where storm drainage is discharged into the main stream. Eroding streambanks are difficult and expensive to repair. Erosion loss can be measured by the cross-section method before and after a storm.

Basic Soils Information—Important for Planning Erosion Control

Knowing basic soils information is important for planning erosion control measures on any given site. Soil texture is based on the combination of individual particles. Particles are classified on the basis of size and fall into the three categories: sand, silt, or clay. The percent of sand, silt, or clay in a soil sample provides the basis for textural classification, such as silt loam or silty clay loam. Three standard soil textural classifications are used: United States Department of Agriculture (USDA), American Association of State Highway and Transportation Officials (AASHTO), and the Unified Soil Classification System (USCS) as described in ASTM D 2487. The limits of the different textural classes are defined within each of the classification systems. See Table 1.1.

A valuable tool in planning for construction activities is the County Soil Survey. This information is available through the Iowa Soil and Water Conservation District (SWCD) extension offices located in each county and is available on the web at ftp://pub.gis.iastate.edu/nrcs/ssurgo/. This survey contains useful information for consultants, planners, engineers, developers, builders, community decision makers, and nearly all other professionals dealing with land use activities.

Table 1.1. Soil textural classes and general terminology used in soil descriptions (Source: US Environmental Protection Agency 1977).

Name	Texture	Basic soil textural common class names
Sandy soils	Coarse	Sand Loamy sand
	Moderately coarse	Sandy loam Fine sandy loam
	Medium	Very fine sandy loam Loam Silt loam Silt
	Moderately fine	Clay loam Sandy clay loam Silty clay loam
Clay soils	Fine	Sandy clay Silty clay Clay

1.2 REGULATORY REQUIREMENTS

Erosion and sediment control requirements exist at the federal, state, and local levels of government. Some local governments (city and county) have adopted site development or sediment control ordinances or regulations, and it is recommended that contractors or developers check with local units of government to determine whether local ordinances may affect their proposed activities.

Federal and State Erosion and Sediment Control Requirements

The U.S. Environmental Protection Agency (EPA) issued final regulations on December 8, 1999, identifying which activities or facilities are now required to have storm water permits. Authority to issue the federal NPDES permits within the state of Iowa has been granted to the Iowa Department of Natural Resources (DNR). Thus, compliance with the federal NPDES storm water permit requirements can be achieved by obtaining a permit from the Iowa DNR. The following three topics are discussed in this section:

1. Identify construction projects that need a permit for their storm water discharge
2. Obtaining a permit for storm water discharge for a construction project
3. Determining the erosion and sediment control requirements needed in the NPDES storm water discharge permit

Construction Projects that Need a Permit for Storm Water Discharge

Effective March 10, 2003, any land-disturbing activity that will “disturb” an area of one or more acres is required to have an NPDES permit for its storm water discharge.

The one-acre limit is based on the “common plan of development.” This common plan of development means that multiple, separate, or distinct construction activities may be taking place at different times on different schedules under one plan. Thus, breaking down a large project into numerous projects of less than one acre does not relinquish the need for a storm water discharge permit. If the overall common plan of development will involve the disturbance of one or more acres, construction on any portion of the project needs to be covered by a storm water discharge permit.

Meaning of the Term “Land-Disturbing Activity”

A land-disturbing activity includes actions that alter the surface of the land. Such activities include, but are not limited to, such actions as clearing, grading, and excavation. Other examples include final grading, building or maintaining construction access roads, filling, and on-site borrowing. All of these areas should be included when estimating the area undergoing any land-disturbing activity.

Meaning of the Term “Storm Water Discharge”

The NPDES permit is required for storm water discharge from any disturbed areas. The term “storm water discharge” refers to any surface runoff from the disturbed areas of the construction site. Construction site storm water runoff results from rainfall runoff or snow melt. The need for a permit applies regardless of the location of the land-disturbing activity.

Obtaining a Permit for Storm Water Discharge for a Construction Project

Storm water discharges from construction activities are eligible (depending on project size) for permit coverage under the Iowa DNR's General Permit No. 2. General Permit No. 2 is an NPDES permit that applies only to storm water discharge from land-disturbing (construction) activity. The general permit specifies up front all of the terms and conditions required and expected to be met. Linking a specific construction project at a particular site to the general permit is done by filing a notice of intent with the DNR. In this way, the owner or general contractor is officially notifying the DNR of the intent to meet the terms and conditions of the general permit. The instructions for filing a notice of intent to be covered under General Permit No. 2, the permit itself, and all other associated forms can be obtained from the DNR website: http://www.iowadnr.com/water/stormwater/index.html.

Erosion and Sediment Control Requirements in the NPDES Storm Water Discharge Permit

Every project must have a pollution prevention plan developed before the notice of intent is submitted to the DNR. The planning and implementation of erosion and sediment control is a crucial component to the pollution prevention plan. Table 1.2 highlights the requirements of Iowa's General Permit No. 2 that relate to erosion and sediment control.

Table 1.2. Requirements in General Permit No. 2 related to erosion and sediment control

Pollution prevention plan	Every project must have a pollution prevention plan developed before the notice of intent is submitted to the DNR. The pollution prevention plan should be kept at the construction site and should be kept up to date. **All contractors and subcontractors involved in land-disturbing activities must sign the pollution prevention plan and become co-permittees of the NPDES permit**. The plan needs to include the following: the sequence of major construction activities and an explanation of how the erosion practices will be phased in with the construction activities; an identification of the selected erosion and sediment controls at the site; each contractor's/subcontractor's role and responsibility in the project and towards erosion and sediment controls; the party(s) responsible for inspection, maintaining, and evaluating the appropriateness of the selected erosion and sediment control practices; and required records of the inspection and maintenance of the sediment and erosion controls.
Run-on controls	To the degree attainable, run-on from undisturbed areas should be diverted from the disturbed areas of the construction site to minimize the amount of area drained for which controls must be provided.
Stabilization practices	During construction, if a disturbed area is to be left idle for more than 21 days, temporary erosion control practices need to be initiated by the 14th day. Temporary erosion control measures include temporary seeding, mulching, geotextiles, etc. These types of practices are aimed at keeping the soil in its original place, rather than capturing it after erosion has occurred.
Structural sediment control	If the area drained is 10 or more acres and there is a common drainageway, a sediment basin with a holding capacity of 3,600 cu ft per acre drained (including off-site area drainage) is to be provided. If a sediment basin is not feasible, comparable erosion control measures on the downslope and sideslopes of the project perimeter are to be provided. For drainage locations serving 10 or fewer acres, structural controls are required for all sideslope and downslope boundaries of the construction area or a sediment basin providing storage for 3,600 cu ft of storage per acre drained must be provided.
Storm water management	The storm water management plan must identify the selected measures that will be installed during construction to control pollutants in storm water discharges that will occur after construction has been completed. After the project is completed and final stabilization is reached, the site's capacity for erosion must be determined? A goal of 80% removal of sediment should be used in designing and installing storm water management practices. Permanent controls may be needed to control erosion from the site. Increased runoff from the site may cause increased erosion downstream. Velocity dissipation devices shall be placed at the discharge location and along the length on any outfall grass channel as necessary to provide a non-erosive flow from the structure to a receiving watercourse.
Inspection and maintenance	Once a week and within 24 hr after a 0.5 in. rainfall, erosion and sediment control practices must be inspected. The practices should be properly maintained and records should be kept. If an existing practice is not working or fails frequently, continued use of that practice should be reevaluated.
Recordkeeping	Records of land-disturbing activities should be kept to determine which areas need to be stabilized. Records on the maintenance and inspection of erosion and sediment control practices must be kept.

State Erosion and Sediment Control Requirements

Iowa law (Code Section 161A.64) requires that before beginning certain land-disturbing activities, the person conducting the activities must file a signed affidavit with the SWCD stating that erosion caused by the activities will not exceed the district's adopted soil loss limits. For most soils, the limit is an annual soil loss of five tons per acre. Forms for filing the affidavit may be obtained from county SWCD offices.

The requirements for filing the affidavit change if a land-disturbing activity is being carried out within the boundaries of a city or county that has adopted a sediment control ordinance are at least as restrictive as the SWCD's soil loss limits. The SWCD retains primary responsibility for the program, but may share authority through a written agreement with the governmental unit. The affidavit must be filed with that governmental unit rather than the SWCD. The SWCD should be contacted to determine whether any local governmental units in the county have adopted sediment control ordinances and have been delegated authority to receive the affidavits.

Land-disturbing activities covered in Code Section 161A.64 include tilling, clearing, grading, excavating, transporting, or filling land that may result in soil erosion from wind and water and the movement of sediment and sediment-related pollutants off-site. However, the following activities are excluded:

- Tilling, planting, or harvesting of agricultural, horticultural, or forest crops
- Preparation for single-family residences separately built unless in conjunction with multiple construction projects in a subdivision development
- Minor activities such as home gardening, landscaping, repairs, and maintenance work
- Surface or deep mining
- Installation of public utility lines and connections, fence posts, sign posts, telephone poles, electric poles, and other kinds of posts or poles
- Installing septic tanks and drainage fields, unless these are to serve a building whose construction is a land-disturbing activity
- Construction and repair of tracks, right-of-way, bridges, communication facilities, and other related structures of a railroad
- Emergency work to protect life or property
- Disturbed land areas of less than 25,000 square feet, unless a political subdivision by ordinance established a smaller exception or established conditions for this exemption
- The construction, relocation, alteration, or maintenance of public roads by a public body

Sediment Damage Complaint Procedure

Iowa law (Code Section 161A.47) allows the owner or operator of land being damaged by sediment runoff from eroding land to file a written and signed complaint with the SWCD. Upon its receipt, the SWCD commissioners inspect the complainant's property to determine whether sediment damage is occurring and inspect the land alleged to be causing the damage to determine whether erosion is causing soil loss in excess of the district's adopted limits. If the investigation finds that sediment damage is occurring as a result of erosion in excess of the limits, the commissioners will take action to have the erosion problem corrected.

A recent change in state law also allows district commissioners to file complaints if they believe excessive erosion is causing sediment damage to public property or to private property where public improvements have been made.

1.3 SOIL EROSION AND SEDIMENT CONTROL MEASURES MATRIX

An erosion control measures matrix has been developed that parallels the three categories of erosion control measures: vegetative and soil stabilization, structural, and special condition erosion control measures. This matrix will enable the designer or planner to quickly review the various options available and the situations in which the options will perform satisfactorily on the basis of various conditions of the proposed construction site.

The matrix takes into account various conditions, including soil erodibility, degree of slope, climate, topography, and season of the year. These conditions have particular criteria:

- **Perimeter Control**. Planned measures installed around the perimeter of the construction site to prevent surface water from damaging the area during or after construction
- **Slope Protection.** Planned measures installed on or above an erosion slope to prevent soil erosion and sedimentation
- **Borrow and Stockpiles.** An area of the construction site where earth is borrowed (excavated to use as fill at another location) or stockpiled (topsoil is temporarily stored) to be respread following construction
- **Drainage Areas.** The area of land above the development site (including the construction site) that naturally contributes water runoff to the area under construction
- **Sediment Trapping.** Planned measures installed below a potentially erosive area, designed to catch eroded soil temporarily until the area above can be stabilized and/or damage to the area below can be prevented
- **Streams.** A water course flowing naturally through a construction site
- **Temporary Stabilizing.** Planned measures installed to provide temporary cover to an erosive area on a construction site while permanent stabilization of the area is being established
- **Permanent Stabilizing**. Planned vegetation or structural measures installed to permanently prevent a constructed area or finished site from eroding
- **Soil.** The makeup of the top surface of a construction site (texture of soil: sand, silt, or clay) must be taken into account in planning and designing measures to control erosion during and after construction. See your County Soil Survey for details
- **Slope.** The inclination of the land surface from the horizontal, with the steeper and longer slopes having the most erosion potential
- **Effectiveness.** The value of each measure to control erosion over a specified period of time

In the following tables (Tables 1.3 through 1.5), each practice has been analyzed according to the criteria and an X has been marked in each section that pertains to the practice. Information pertaining to a given practice is found on the front and back of each page.

Table 1.3. Vegetation and soil stabilization erosion control measures

Measure	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Compost blanket	A 1- to 4-inch surface application of compost/mulch or a blend to protect areas with erosive potential		X			X		X	X		X		X	X		X	X			X	
Compost filter tube	A tubular mesh sock filled with a specified blend of composted materials, used to slow flow velocity, capture and degrade chemical pollutants, and trap sediment		X			X		X	X	X	X		X	X		X	X		X		
Dust control	A chemical applied to an exposed soil to prevent the movement of dust		X					X		X	X	X	X	X	X				X		
Flocculents	Natural materials or a class of chemicals that cause colloidal particles (clay) to coagulate; the coagulated particles group together to form flocs that will settle out of detained stormwater					X													X		
Grass channels	A temporary drainageway to convey runoff through, along, or around an area; these can be established to serve as permanent controls				X	X	X	X		X	X	X	X			X	X	X	X	X	X
Mulching	Applying plant residue or other suitable material to protect the soil surface		X	X	X			X	X	X	X	X	X	X	X	X			X		
Rolled erosion products (RECP)	Prefabricated blankets or netting which are formed from both natural and synthetic materials		X			X		X	X	X	X		X	X		X	X		X		
Seeding and fertilizing	Seeding grasses and legumes on disturbed soil areas **Note: A ground cover of grass is the most effective method of controlling erosion**		X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X
Sodding	Bare soil covered with cut sod, usually bluegrass, to provide rapid ground cover and stabilization of the soil; often used in waterways and flumes		X		X				X		X	X	X	X	X	X	X				X
Stream channel vegetation	The use of vegetation to retard stream channel and bank erosion and maintain soil stability				X		X		X	X	X		X	X		X	X	X	X	X	X
Surface roughening	A rough finish on clay soils; this procedure should generally be limited to use only after the fall seeding period has passed to carry a site through the winter months		X					X				X	X	X	X	X			X		
Vegetative filter strip	A strip of grass planted at right angles to the flow of runoff; a 30-foot width is desirable, though as little as 10 to 15 feet can be helpful	X	X			X		X	X		X	X	X	X	X	X				X	X
Wattles	A sediment and stormwater velocity control device, generally tubes of straw, rice straw, or coconut husk encased in ultraviolet (UV) degradable plastic netting or 100% biodegradable burlap material; wattles help stabilize slopes by breaking up the length and by slowing and spreading overland water flow		X			X		X	X	X	X		X	X		X	X		X		

Key

A	Perimeter Control	H	Permanent Stabilizing	O	Drainage Area < 1 acre
B	Slope Protection	I	Soil – Sandy	P	Drainage Area 1-5 acres
C	Borrow and Stockpiles	J	Soil – Silty	Q	Drainage Area > 5 acres
D	Drainage Areas	K	Soil – Clay	R	Effectiveness < 6 mo
E	Sediment Trapping	L	Slope 0% - 3%	S	Effectiveness 6-12 mo
F	Streams	M	Slope 3% - 8%	T	Effectiveness > 12 mo
G	Temporary Stabilizing	N	Slope > 8%		

Table 1.4. Structural erosion control measures

Measure	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Bench	A slightly reverse sloping step on a back slope to reduce slope length		X	X				X	X			X	X	X	X	X			X	X	X
Compost filter berm	A temporary or permanent ridge of soil located so runoff water is channeled to a planned location		X		X		X	X	X		X	X	X	X	X	X	X	X	X	X	X
Check dam	A small temporary barrier or dam constructed across a drainage ditch				X	X		X				X	X	X		X			X	X	X
Diversion structure	A temporary or permanent dike or compost filter berm located so water can be directed to a planned location	X	X		X			X	X	X		X	X	X		X	X		X	X	X
Temporary slope drain	A temporary structure, either metal or flexible pipe, used to carry runoff water from the top of a slope to the bottom	X	X		X	X		X	X	X	X	X	X	X	X	X			X	X	X
Energy dissipator	An obstacle placed at the outlet of a drainage pipe or where a rapid flow of water needs to be reduced to prevent erosion				X		X	X	X	X	X		X	X	X		X	X	X	X	X
Flotation silt curtain	A silt curtain used in a lake or pond to keep silt-laden water within the construction area						X	X		X	X	X	X			X	X	X	X	X	
Rock chutes and flumes	A device to transport water in a structure to a lower level without erosion		X		X			X	X	X	X	X	X	X	X	X	X		X	X	X
Silt fence	A temporary barrier of geotextile fabric used to intercept sediment on small drainage areas; one of the most convenient control measures to use on all projects	X	X	X	X	X		X	X	X	X	X	X	X		X	X		X	X	
Gabion	A rectangular wire mesh box filled with rock and used in a variety of places where heavy flexible reinforcement is necessary		X		X		X		X	X	X	X	X	X		X	X	X	X	X	X
Inlets	A structure to accept surface runoff and dispose of water in a storm water disposal system				X	X	X		X	X	X	X	X	X	X	X	X		X	X	X
Jetties	A structure used to deflect water current away from selected sections of a streambank				X		X		X	X	X	X	X			X	X	X	X	X	X
Level spreader	A water flow outlet device constructed at zero grade so concentrated runoff may empty at non-erosive velocity onto an area stabilized with existing vegetation		X		X			X			X	X	X			X	X		X	X	
Pipe outlet	An apron or other energy dissipating device placed at the outlet of a drainage pipe		X		X			X	X		X	X	X	X		X	X		X	X	X
Retaining wall	A constructed wall to assist in the stabilization of cut or fill slopes where permissible slopes cannot be obtained without the use of a wall	X	X		X				X	X	X	X	X	X		X			X	X	X
Riprap	A permanent erosion resistant ground cover of large, graded, loose angular stone used where water erosion is a problem		X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Stabilized construction entrance	A crushed rock or gravel stabilized pad located at points of vehicular ingress or egress at a construction site	X						X	X		X	X	X	X		X	X		X	X	X
Sediment barrier	Temporary structures that allow water-borne silt to settle in the structure while the water continues on				X	X		X		X	X	X	X	X		X			X		
Sediment basin	A basin created by building a dam across a waterway or by excavation or a combination of both; a sediment basin usually consists of a dam, a pipe outlet, and an emergency spillway				X			X			X	X	X	X		X	X		X	X	X
Sediment trap	A depressed area in drainage areas that allows the runoff to slow and the silt to settle				X	X		X		X	X	X	X	X		X			X		
Streambank protection	A permanent structure that will stabilize an eroding streambank				X		X		X	X	X	X	X			X	X	X	X	X	X
Subsurface drainage	A perforated pipe, tubing, or tile installed beneath the ground surface to intercept and convey ground water for suitable disposal	X	X		X			X	X	X	X		X	X		X	X		X	X	X

Key

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D	Drainage Areas	K	Soil – Clay	R	Effectiveness < 6 mo
E	Sediment Trapping	L	Slope 0% - 3%	S	Effectiveness 6-12 mo
F	Streams	M	Slope 3% - 8%	T	Effectiveness > 12 mo
G	Temporary Stabilizing	N	Slope > 8%		

Table 1.5. Special conditions erosion control measures

Measure	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Retention pond	A permanent pool of water that has the capacity to store storm water until it is released from the structure				X	X			X			X	X					X			X
Infiltration basin and trench	A depressed area formed by the removal of overburden to expose a porous or sandy soil that allows a flow of runoff water to be absorbed; may also be constructed by excavating a trench and filling it with suitable porous soil				X			X	X	X	X	X	X			X	X	X			X
Serrated cut	Stairstep grading used in soils containing large amounts of soft rock where it may be impossible or impractical to smooth grade		X						X												X
Stream crossing	A temporary structure installed across a flowing stream for use by construction equipment				X		X	X		X	X	X	X					X			X
Wetlands	Important control measure for removal of sediment, nutrients, and urban pollutants by passing runoff water through a constructed wetland area				X	X	X		X	X	X	X	X			X	X	X			X

Key

A	Perimeter Control	H	Permanent Stabilizing	O	Drainage Area < 1 acre
B	Slope Protection	I	Soil – Sandy	P	Drainage Area 1-5 acres
C	Borrow and Stockpiles	J	Soil – Silty	Q	Drainage Area > 5 acres
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E	Sediment Trapping	L	Slope 0% - 3%	S	Effectiveness 6-12 mo
F	Streams	M	Slope 3% - 8%	T	Effectiveness > 12 mo
G	Temporary Stabilizing	N	Slope > 8%		

1.4 EROSION AND SEDIMENT CONTROL PLAN PREPARATION

This chapter is a guide for the preparation of an erosion and sediment control plan for a construction project. The plan describes the potential for erosion and sedimentation problems on a construction project. The plan also identifies and explains the measures that are to be taken to control those problems. The erosion and sediment control plan must contain sufficient information to ensure that erosion and sedimentation have been adequately addressed for the proposed project. The control plans for a single house development will be far less complicated than a large development on steep slopes or rough terrain.

This plan should have two parts: the written portion or narrative and the map or site plan. The narrative explains the erosion and sediment control decisions for a particular project and the justifications for those decisions. It is important that adequate information is provided in the narrative.

The owner or lessee of the land being developed is responsible for the plan preparation. The owner or lessee may engage an engineer or other qualified person to prepare the plan; however, the owner or lessee still has the responsibility for ensuring development of an acceptable plan.

Plan Preparation

Five steps are needed for adequate development of an erosion and sediment control plan:

1. Data inventory
2. Data analysis
3. Site plan development
4. Erosion and sediment control plan
5. Plan preparation

Step 1. Data Inventory

Gather information that will help develop the most effective erosion and sediment control plan. The information obtained should be plotted on a map and explained in the narrative portion of the plan. Such a narrative should include the following topics:

- **Aerial photo of site**. An aerial photo of the site and adjacent lands should be obtained and used to identify important site characteristics, as well as features of adjacent lands that should be considered in developing the erosion and sediment control plan. A color infrared map and a soils map of a site can be obtained from the following website: http://igsims.igsb.uiowa.edu/website/basic/viewer.htm.
- **Topography**. A topographic map of the site should be prepared to show the existing contour elevations at intervals of 1–5 feet, depending on the slope of the ground.
- **Drainage patterns**. All existing drainage ditches and swales must be located and indicated on the topographic map.
- **Soils**. Major soil types should be shown on the topographic map or on an overlay of the same scale for ease of interpretation.

- **Ground cover**. The existing vegetation on the site should be shown. Features such as trees, shrubs, grassy areas, native grasses, and existing denuded or exposed soil and rock outcrops should be indicated.
- **Adjacent areas (upstream and downstream)**. Areas adjacent to the proposed development site should be indicated on the topographic map, including features such as streams, roads, buildings, and wooded areas. Anticipated runoff velocities and volumes from those areas should be calculated to determine the types of erosion control or flow diversion techniques that should be employed on the construction site. Streams that will receive runoff from the site should be surveyed to determine their carrying capacity and ways to control sedimentation prior to water leaving the site.

Step 2. Data Analysis

When the information in Step 1 is compiled, a picture of the site possibilities begins to emerge. The important points to consider in site analysis are as follows:

- **Topography**. The primary considerations are slope length and steepness. Longer and steeper slopes will increase the runoff flow and the erosion potential. When the percent of slope has been determined, areas of similar steepness should be grouped together. Slope gradients should be grouped into three general ranges of soil erodibility:

  0%–3%—low erosion potential
  3%–8%—medium erosion potential
  over 8%—high erosion potential

  Within these slope ranges, the greater the slope length, the greater the erosion potential. Generally the erosion potential becomes more serious if the slope lengths exceed the following distances:

  0%–3%—300 feet
  3%–8%—150 feet
  over 8%—75 feet

- **Drainage patterns**: Natural drainage patterns exist on the land. These patterns, which consist of overland flow, swales and depressions, and natural waterways, need to be identified so that critical areas can be located where water will concentrate. The natural waterways should be used wherever possible rather than incurring the expense of constructing and maintaining an artificial waterway. Care should be taken ensure that any increase in runoff from the site will not erode or flood the existing drainage system or cause downstream damage. Such a location may require a retention pond.
- **Soils**. Soil characteristics need to be identified to determine permeability, shrink-swell potential, texture, erodibility, and water table depth and depth to bedrock. This information can be obtained from the local SWCD office or from the following website: http://www.itc.nl/~rossiter/Docs/NRCS/620nsh.pdf.
- **Ground cover**. A dense grass ground cover is the most important feature for preventing erosion. All existing vegetation that can be saved will help prevent erosion. This includes trees, shrubs, and other vegetative cover. Construction that can be staged, which involves stabilizing one part of the site before disturbing another, will reduce the erosion potential as well as the amount of temporary seeding and mulching required.

- **Adjacent areas**. Careful analysis of adjacent properties, especially areas upslope and downslope from the construction project is necessary. To prevent erosion from occurring in the construction area, upstream property runoff velocities and volumes must be controlled as they enter the site or flows must be diverted. Special consideration must be given to watercourses that will receive runoff directly from the construction site. The potential for sediment pollution of the watercourses needs to be considered, as well as downstream erosion due to an increased volume of runoff. The potential for sediment deposition on adjacent properties due to sheet and rill erosion should also be considered so appropriate sediment trapping measures can be planned.

Step 3. Site Plan Development

After reviewing the data and noting the site limitations, development of the site plan can begin. The planner should locate the proposed buildings, roads, and parking areas, and develop a landscape plan to exploit the strengths and take into account the limitations of the site. The following items should help in the planning decisions:

- **Fit the development to the site conditions**. Doing so will avoid unnecessary land disturbance, minimize cut and fill, and reduce erosion potential and development costs.
- **Limit construction activities to the least critical areas**. Land disturbance of the more erodible areas will require the installation and maintenance of costly control measures. Cluster buildings together: this plan will reduce the amount of disturbed area. Concentrating utility lines and connections in one area will provide more natural open space. The cluster concept lessens the erodible area, reduces runoff, and usually reduces development costs.
- **Minimize paved areas**. Keep paved areas such as roads, drives, and parking lots to a minimum. The more land kept in vegetative cover, the more water will infiltrate, thus minimizing runoff and erosion.
- **Use the natural drainage system**. By retaining the natural drainage system, the potential for downstream damage due to increased runoff can be minimized and storm water management made easier.

Step 4. Erosion and Sediment Control Plan

Once the plan for the site has been decided, a plan to control erosion and sediment from the disturbed areas must be prepared.

The planner should refer to Section 1.6 of this manual, “Implementation Guidelines, Erosion Control Measures,” to help select the most appropriate control measure. The following procedure is suggested for erosion and sediment control planning:

- **Determine the limits of clearing and grading**. Determine which areas must be disturbed for the proposed construction. Note critical areas that must be disturbed.
- **Divide the site and adjacent runoff-contributing properties into individual drainage areas**. Determine how the runoff will travel over the site. Determine how erosion and sedimentation can be controlled in each small drainage area before reviewing the whole site. It is easier to control erosion than to contend with sediment after it has been carried downstream.
- **Select erosion and sediment control measures for the construction site and the runoff contributions of adjacent runoff contributing areas**. Erosion and sediment

control measures can be divided into three categories: vegetation and soil stabilization measures, structural measures and special conditions.

- *Vegetation and soil stabilization measures.* The objective is to prevent erosion and to protect the soil from the impact of raindrops and the overland flow of runoff. The best way to protect the soil is with a cover of grass. If disturbance is necessary, seed, mulch, and fertilize the area as soon as possible. If the area will be disturbed again, then temporarily seed the area and mulch if necessary. The erosion and sediment control plans must contain provisions for permanent stabilization of the disturbed areas. Selection of permanent vegetation should include the following considerations: establishment requirements, adaptability to the site, aesthetics, and maintenance requirements.
- *Structural measures.* Structural measures are generally more costly and less efficient than vegetation. Nevertheless, they are usually necessary, since not all disturbed areas can be protected with vegetation. However, it is very important that the structural measures selected be designed and installed according to standard engineering practices. Improper use or incorrect installation can create larger problems than those the structure was designed to solve.
- *Special conditions*. These measures are needed for special situations and may require a special design for an installation.

- **Storm water permit requirements.** Land-disturbing activities that will disturb an area of one or more acres are required to be covered by an NPDES permit. The stormwater permits are managed by the Environmental Services Division of the Iowa DNR, Wallace State Office Building in Des Moines, Iowa.

Step 5. Plan Preparation

The planning work has been done in Steps 1–4. The final step consists of consolidating the pertinent information and developing a specific erosion and sediment control plan for the project. The plan consists of two parts: a narrative and a site plan. The narrative explains the problems and the solutions, along with necessary documentation. The site plan is one or a series of maps or drawings showing the location of the various control measures. The following checklist should be included in the plan:

- **Description**. Describe the land, purpose, and the amount of grading involved.
- **Site conditions**. Describe the existing topography, vegetation, and drainage.
- **Adjacent areas**. Describe the neighboring areas, drainageways, buildings, streams, roads, land use, etc.
- **Soils**. Briefly explain the soils, soil names, soil depth, erodibility, and texture.
- **Critical areas**. Note areas on the site that have potentially serious erosion problems.
- **Erosion and sediment control measures**. The measures selected for use on the site are listed and illustrated in Chapters 2–4 of this document.
- **Permanent stabilization**. Briefly describe how the site will be stabilized after construction is completed.
- **Stormwater permit requirements**. Identify whether the development of the site will increase the runoff and whether a discharge permit will be required.
- **Maintenance**. Provide a schedule for inspection and repair of erosion and sediment control measures.

- **Calculations**. Calculations for the design of such items as sediment basins, diversions, waterways, and retention basins should be included.
- **Wetlands**. Identify steps to be taken to comply with all regulations and include drainage patterns.

The following checklist should be included in the site plan:

- **Location map**. Show the location of the proposed construction site in relation to the surrounding area on the map.
- **Identify owner and developer**.
- **North point**. Indicate the north point and the scale.
- **Contours**. Show the existing contours of the site on a map.
- **Existing vegetation**. Show tree and shrub lines, grassy areas, or special vegetation on a map.
- **Soils**. Show the boundaries of different soil types on a map.
- **Critical erosion areas**. Indicate areas with the potential for serious erosion problems on a map.
- **Drainage patterns**. Show the dividing lines and the direction of flow for the different drainage areas on the map.
- **Final contours**. Show changes to the existing contours on a map.
- **Clearing and grading**. Outline areas to be cleared and graded on a map.
- **Location of control measures**. Indicate the location of the various erosion and sediment control measures on a map.
- **Drawings**. As necessary, provide detailed drawings and explanations of structural control measures, especially for measures not referenced in this manual.

1.5 SAMPLE SITE PLANS

In this section, all information presented in Section 1.4, "Erosion and Sediment Control Plan Preparation," will be put to use in the development of an erosion and sediment control plan for a proposed construction project. Since this is an exercise, the development of the sample plan will be brief; however, it is important that all issues be addressed.

Plan Development

The erosion and sediment control plan for this project was developed according to the step-by-step procedure outlined in Section 1.4. For training purposes, each step is discussed separately with corresponding maps to illustrate what was done. This plan consists of four maps, shown in Figures 1.2 through 1.5, though information on Figures 1.2 and 1.3 could have been combined on one map. However, planners may choose the method they wish to present the information.

Step 1: Data Collection (Figure 1.2)

The topographic information was obtained by aerial survey and shown on the map in Figure 1.2 at a scale of 1 in. = 200 ft, with 2 ft contours.

From an on-site inspection, as shown on the topographic map, the site has three watersheds, each drained by a distinct swale. Land use and slopes of adjacent upstream properties must also be identified to analyze the potential overland control needs.

The soils information is available from the SWCD office. This site has slopes that range from a 2% to a 25% grade. Each soil type is identified by a symbol. The first two numbers identify the soil name; the letter B, C, or D indicates the degree of slope, from gently sloping to moderately steep. The final number, 2 or 3, indicates whether the soil is currently in an eroded or severely eroded condition. The lack of a final number indicates slight to no erosion.

An on-site investigation was made to determine the existing vegetation. Tree lines are shown on the top of the map along with the type of grass cover on the site.

The land use of the adjacent properties is indicated on each side of the proposed development tract.

Step 2: Data Analysis (Figure 1.3)

In terms of topography, the site consists of a series of ridges and valleys running from west to east. The areas that have the steep (10% to 20%) slopes should be avoided if possible.

The three major drainage areas identified as areas I, II, and III on Figure 1.2 have approximately 35 acres, 20 acres, and 28 acres, respectively. Each area is drained by a well-defined swale. These swales should continue to be used. Extreme care should be exercised to control any erosion that might occur during construction.

Information about the major soil types should be related in the narrative. Soils that have a high degree of erodibility should be noted on the map.

Ground cover conditions should be noted, and the growth that should be saved should be identified in the field and on the development plans.

The adjacent areas downstream must be protected from large flows of sediment during construction. The flow intensity across the site should be managed to retain sediment on site and prevent downstream erosion. Adequate erosion and sediment control measures must be in place before construction begins. The two highways should be protected from the possibility of construction traffic tracking mud on them.

Step 3: Site Plan Development (Figure 1.4)

Figures 1.2 and 1.3 were used to determine the most suitable areas for development and the most critical areas from an erosion control standpoint. Erosion potential is a factor to be considered in locating the many features of the plan.

The final site plan, shown in Figure 4, was developed through a balanced evaluation of such factors as convenience, drainage, maintenance, costs, aesthetics, and erosion potential during construction and stormwater runoff after construction.

Access roads were located to follow the existing topography as nearly as possible so that grading could be minimized.

The two major buildings were located on either side of the swale in Drainage Area II with a connecting walkway to minimize disturbance within the swale.

The parking areas were clustered around the buildings for convenience and to centralize land disturbance in one major area.

The existing drainage swales were preserved to continue draining the site. A storm sewer was located along the swale in Drainage Area I to follow the existing grade and minimize land disturbance.

The tennis courts and ball fields were located to take advantage of the flattest areas on the site. Although the ball field is located over a highly erosive soil, the flat grade should minimize erosion.

Development is basically confined to Drainage Areas I and II. There will be no increase in erosion potential in Drainage Area III during construction. There should be no potential for damage to adjacent areas on the southern border of the site, and flow intensity changes should be minimized. Care should be taken to reduce the velocity and volume of runoff during and immediately after a rainfall event.

Step 4: Erosion & Sediment Control Plan Preparation (Figure 1.5)

The limits of grading are outlined on the site plan (in Figure 1.4) so the areas requiring erosion and sediment control practices can be determined. Because construction will take place in two separate drainage areas, the erosion and sediment control plans were considered for each drainage area as follows:

Drainage Area I

Land disturbance in this area consists of grading access roads, a parking area, tennis courts and a baseball field. The objective is to keep sediment from entering the natural drainage swale leading to Courthouse Creek. This will be done by a combination of management and vegetative methods to minimize erosion potential and structural measures to retain sediment that is unavoidably generated.

Drainage Area II

The major portion of the construction will take place in this area. This includes grading for three buildings, three parking lots and access roads, and future buildings and parking. A storm sewer system is also planned to be built along the swale.

It is likely that a considerable amount of sediment and an increased level of runoff flow will enter the drainage swale during construction. The objective will be to reduce flow velocities and minimize erosion by using vegetative controls and management methods to trap sediment before it enters the creek.

Structural Controls, Area I

1. A system of temporary diversion structures and sediment traps below the graded areas will be used to trap and filter sediment before it enters the drainage swale.
2. A temporary construction entrance will allow muddy tires to be cleaned before entering the highway.
3. The potential exists for erosion at the outlets of drainage pipes. Thus, riprap is planned at the outlets to dissipate energy and prevent erosion.
4. Not shown in the example are measures required to control the flow from upstream properties and along the perimeter at the outlet of each drainage area. Control measures placed to intercept adjacent property runoff must consider land use vegetation changes over the time of construction. Perimeter measures must consider the potential for failure or overload of the on-site erosion control measures.

Structural Controls, Area II

1. Drainage Area II is completely drained by a single swale. A sediment basin constructed across the swale below all construction is the most effective method to remove sediment from runoff before it enters the creek.
2. Sediment-laden water will be filtered before entering the storm drain system during construction. The type of inlet protection being used should be clearly identified.
3. A cluster of trees and other vegetation should be protected from sediment deposition during construction. A silt fence will provide the necessary protection.

Vegetative Measures, Areas I and II

1. Topsoil will be stripped, stockpiled, and spread at a later time. Stockpiles should be located in a safe area and protected by seeding and mulching.
2. Temporary seeding will be done on graded areas where further work will be delayed three weeks. Diversion structures and the sediment basin embankment will also be seeded with temporary seeding.
3. Permanent seeding will be applied in accordance with the overall landscape plan for the site.

4. An excelsior mat will be used as a temporary liner in all the drainage ditches and as an aid in grass establishment

Management, Areas I and II

1. Construction traffic will be limited to access roads and areas to be graded. All traffic will be prohibited from crossing drainage swales and streams, except where necessary.
2. The sediment basin, diversion structures, and sediment traps will be installed as a first step in grading.
3. As soon as the major grading is done, temporary or permanent seeding will be applied in the respective areas.
4. Responsibility for implementing the plan should be transferred to the construction superintendent. The superintendent should make all workers aware of the provisions of the plan.
5. All erosion and sediment control measures should be checked continuously and after each significant storm to locate and repair damages and conduct maintenance operations.

Step 5. Prepare the Plan

In Steps 1–4, all of the information necessary for preparing an erosion and sediment control plan was developed. In this final step, the actual plan is to be prepared containing all of the pertinent information in a logical format. The checklist at the end of Section 1.4 was used as a basis for developing the erosion and sediment control plan as shown in Figures 1.2–1.5.

Figure 1.2. Data collection worksheet

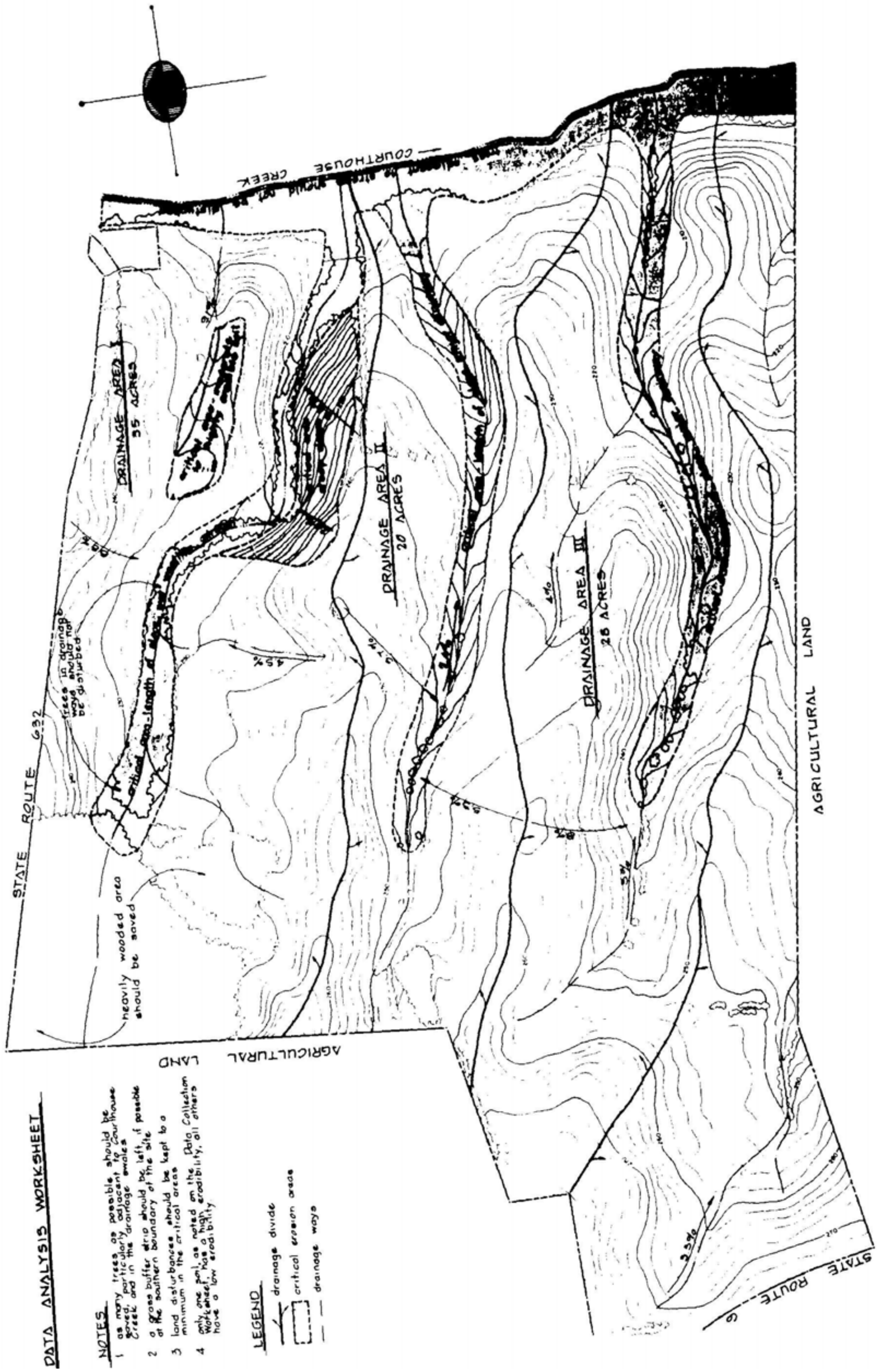

Figure 1.3. Data analysis worksheet

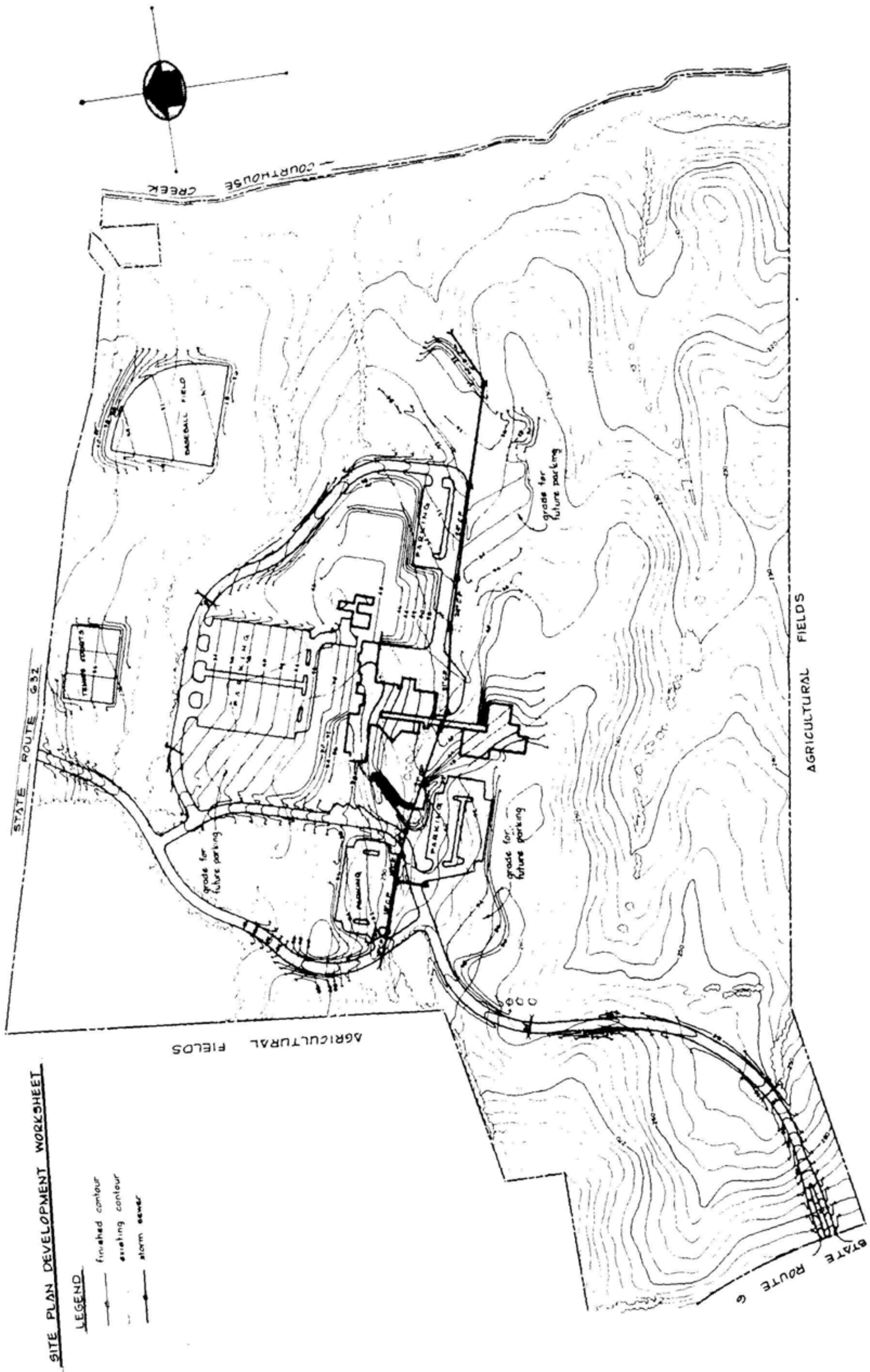

Figure 1.4. Site plan development worksheet

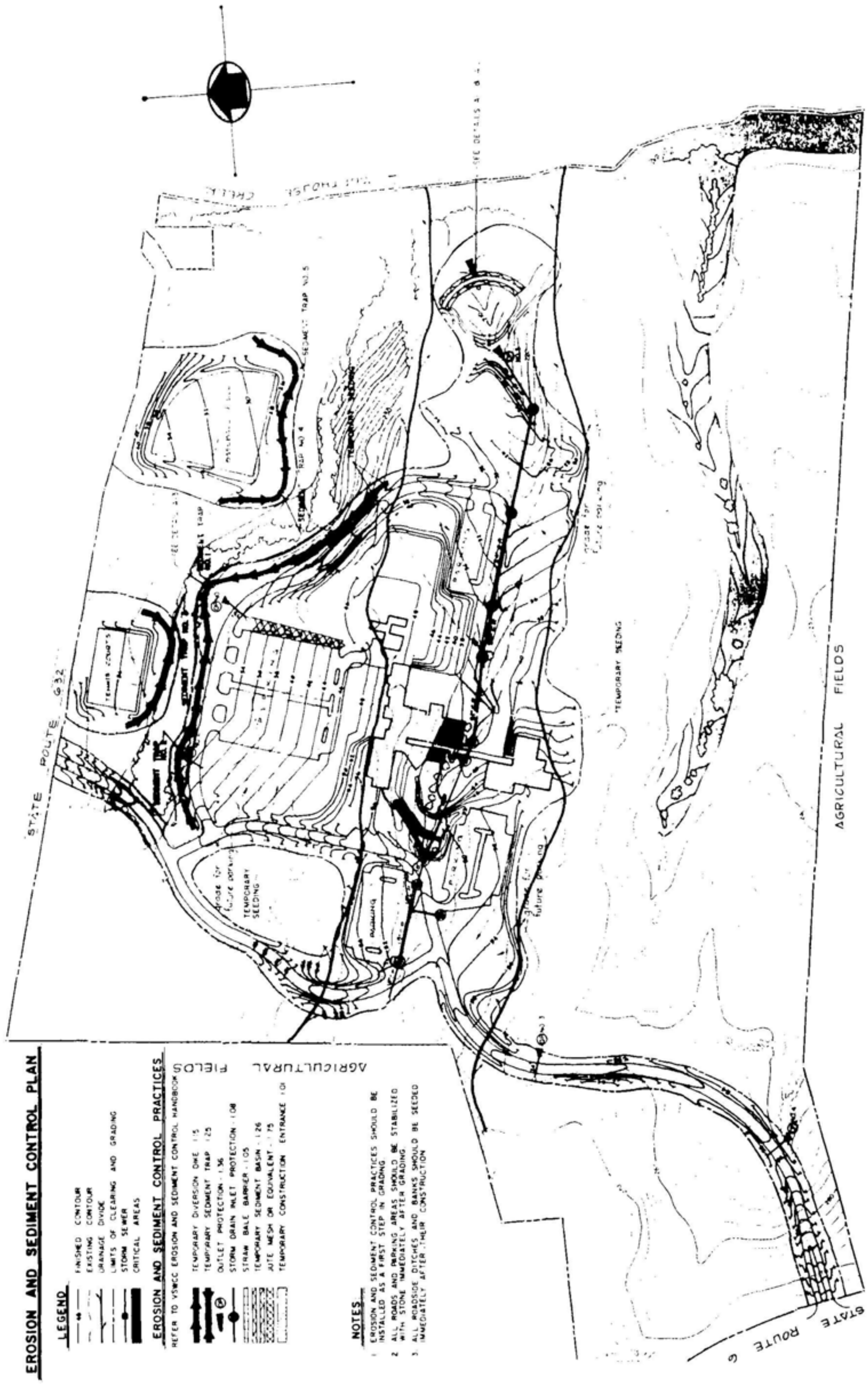

Figure 1.5. Erosion and sediment control plan

1.6 IMPLEMENTATION GUIDELINES

Planning

Planning is necessary if effective solutions are to be provided for erosion and sediment control on construction sites. Plans can guide development and prevent waste. In planning, the permanent features of the development should conform to the natural characteristics of the site.

Soil survey information provides an understanding of the capabilities and general limitations of a site. The soil survey contains information on the feasibility of planned land uses, economic considerations, and the conservation requirements of the site. Detailed soil maps and related data are available in the local SWCD offices and will provide the following information:

1. Descriptions, erodibility, capabilities, and construction limitations
2. Soil properties and suitability of soil material for topsoil, gravel, and sand or for dams and levees
3. Construction site suitability for roads, buildings, septic systems, sanitary landfills, vegetation, reservoirs, dams, recreation areas, or wildlife development

Addresses, fax numbers, and phone numbers of the local SWCD offices can be found at http://www.agriculture.state.ia.us/swcdnm.asp.

An erosion and sediment control plan is necessary for all of the land to be developed. A great deal of information must be reviewed to develop an effective plan for the construction site. The erosion and sediment control plan needs to show the existing topography and how it will be changed. The plan needs to indicate what control measures will be used and how and when they will be installed, maintained, and coordinated with the phasing schedule.

Site Management

Efficient site management for effective erosion and sediment control may involve the following considerations:

- Keep silt on the construction site.
- Clear and grade only what is needed for immediate construction; avoid complete clearing and grading; stabilize disturbed areas as soon as possible; divert runoff from highly erodible soils and steep slopes.
- Mark protected areas so workers can see the area. Plastic snow fencing is a good material to use to protect and define the area.
- Ensure all workers understand the provisions of the erosion and sediment control plan.
- Have one person responsible for implementing the erosion and sediment control plan.
- Arrange for routine inspection of all erosion and sediment control measures. When the sediment traps are half-full, they should be cleaned and the sediment disposed of on-site and in an area where sediment will not fill the trap during the next precipitation event. Inspections should be made of all control measures following each precipitation event.

As an aid in planning, refer to the flow charts in Figures 1.6–1.8.

Drainage

Safe disposal of runoff water from a construction site is a major concern. For information about drainage ditch design, see the Natural Resources Conservation Service Engineering Field Handbook. A major item in ditch design is stability of the soil.

Vegetated Channels

The following information will be helpful in designing channels and waterways. Additional details may be found in Chapter 2 under Vegetation and Soil Stabilization Erosion Control Measures: Grass Channels.

When the channel can be protected from erosion, the allowable velocities can be increased, resulting in deeper and narrower channels. An inexpensive and permanent form of protection is vegetation, specifically grasses. Vegetation protects the channel material from the erosive action of the flow and binds the channel material together.

Vegetated waterways generally can be used to carry intermittent flows such as storm water runoff. However, they are not recommended for channels having sustained base flow, as most vegetation cannot survive continual submergence or continual saturation in the root zone. For example, vegetated waterways would not be used as the channel carrying the discharge from a pipe spillway in a detention basin because this flow is likely to be sustained. A compound channel with a small, lined channel in the center to carry base flows and a vegetated portion to carry storm flows may be used in these situations.

Vegetated waterways are somewhat more complex to design and require more care in their establishment than waterways without vegetation. They will carry high flows at high velocities and require a minimum of maintenance if properly constructed.

Typically, a tall grass presents a great deal of flow resistance to shallow flow. As the flow depth increases, the resistance may decrease. Often the grass will lay over in the direction of flow when the flow reaches sufficient depth. In this condition, the resistance is considerably reduced as compared to the shallow flow situation.

Grasses have been divided into five classes by their ability to retard flow (retardance). The classes are designated A, B, C, D, and E. If the grass will be mowed part of the time and left long part of the time, both the flow conditions and retardance classes must be considered. See Tables 1.6–1.8 for flow retardance classification.

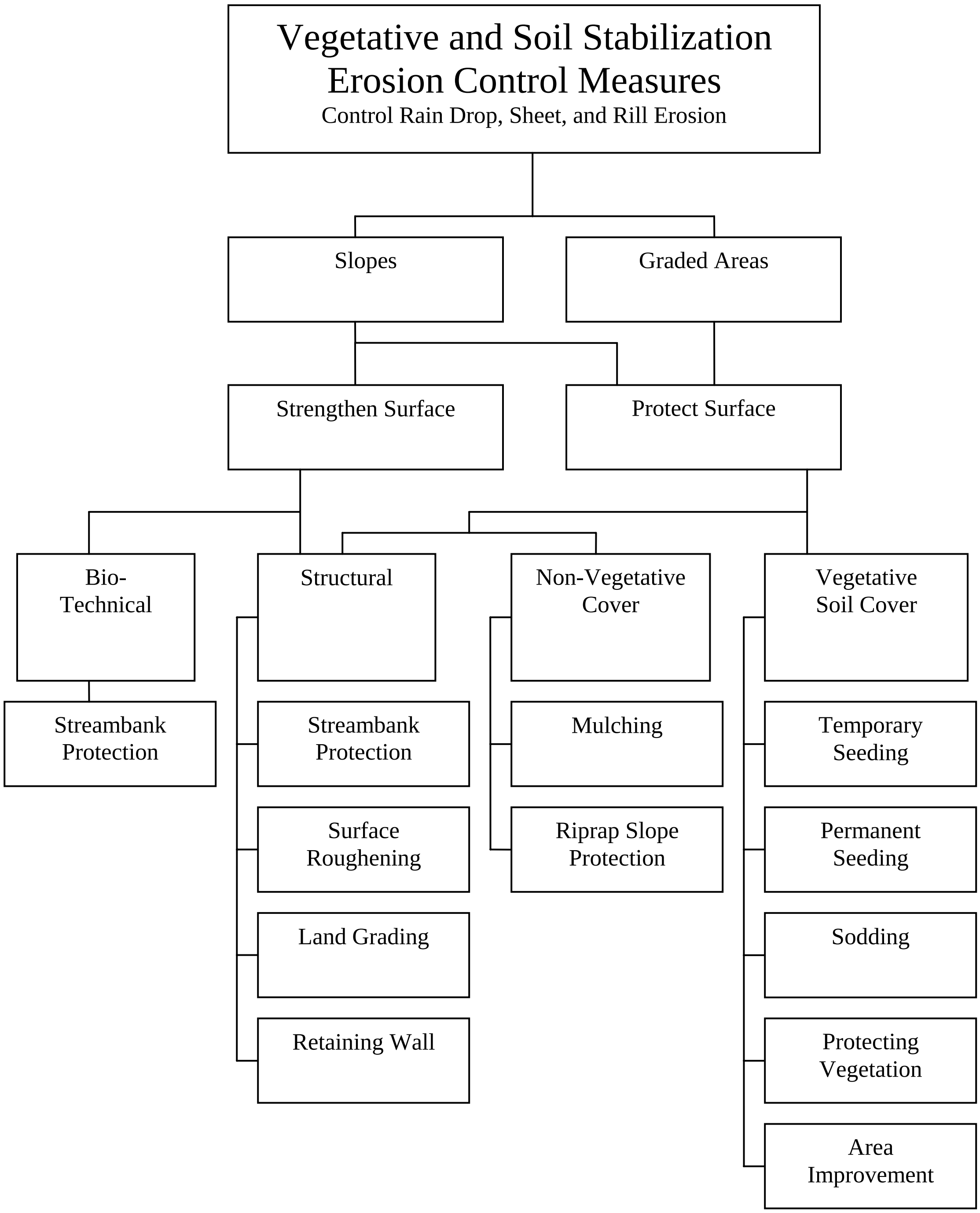

Figure 1.6. Vegetative and soil stabilization erosion control measures

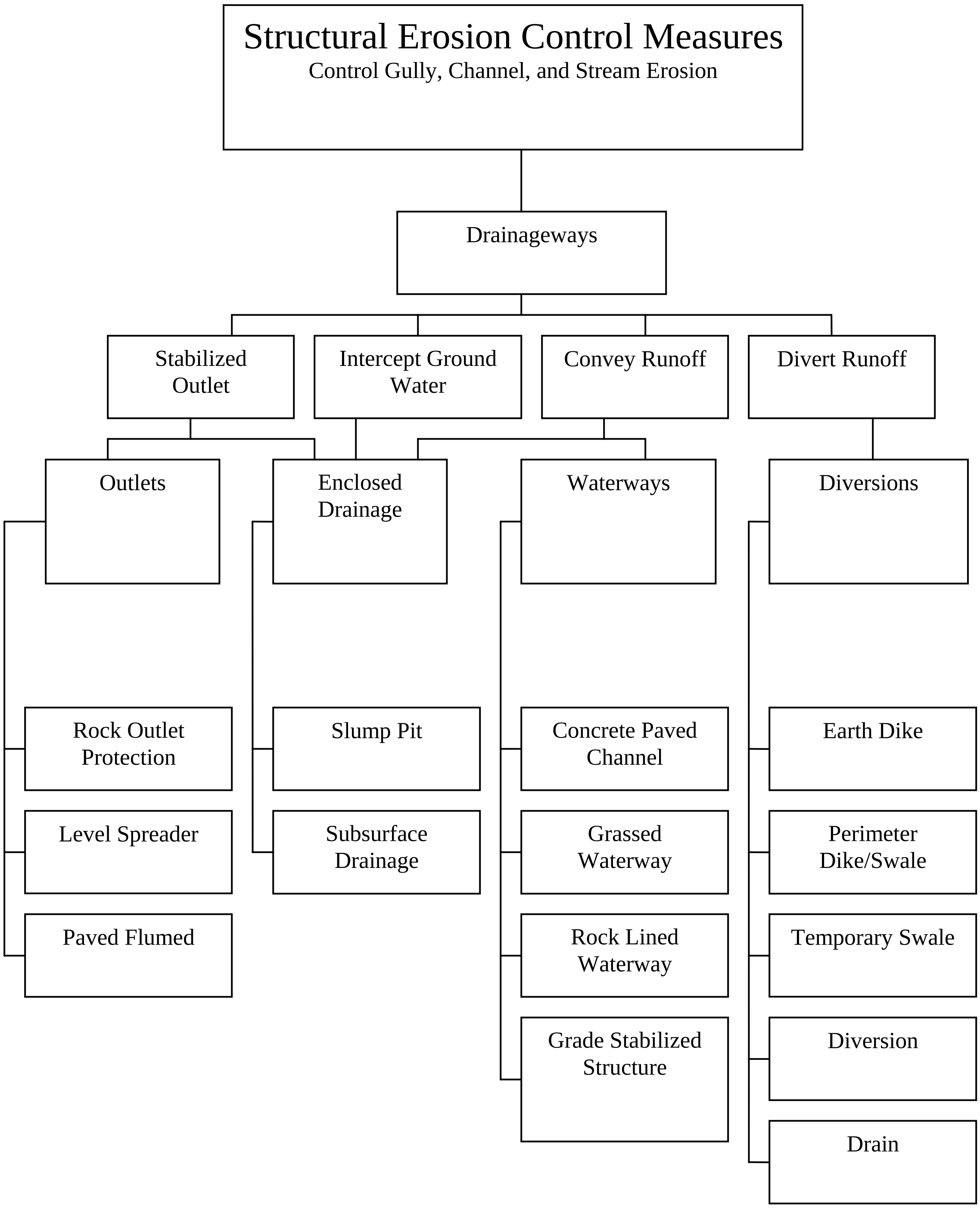

Figure 1.7. Structural erosion control measures

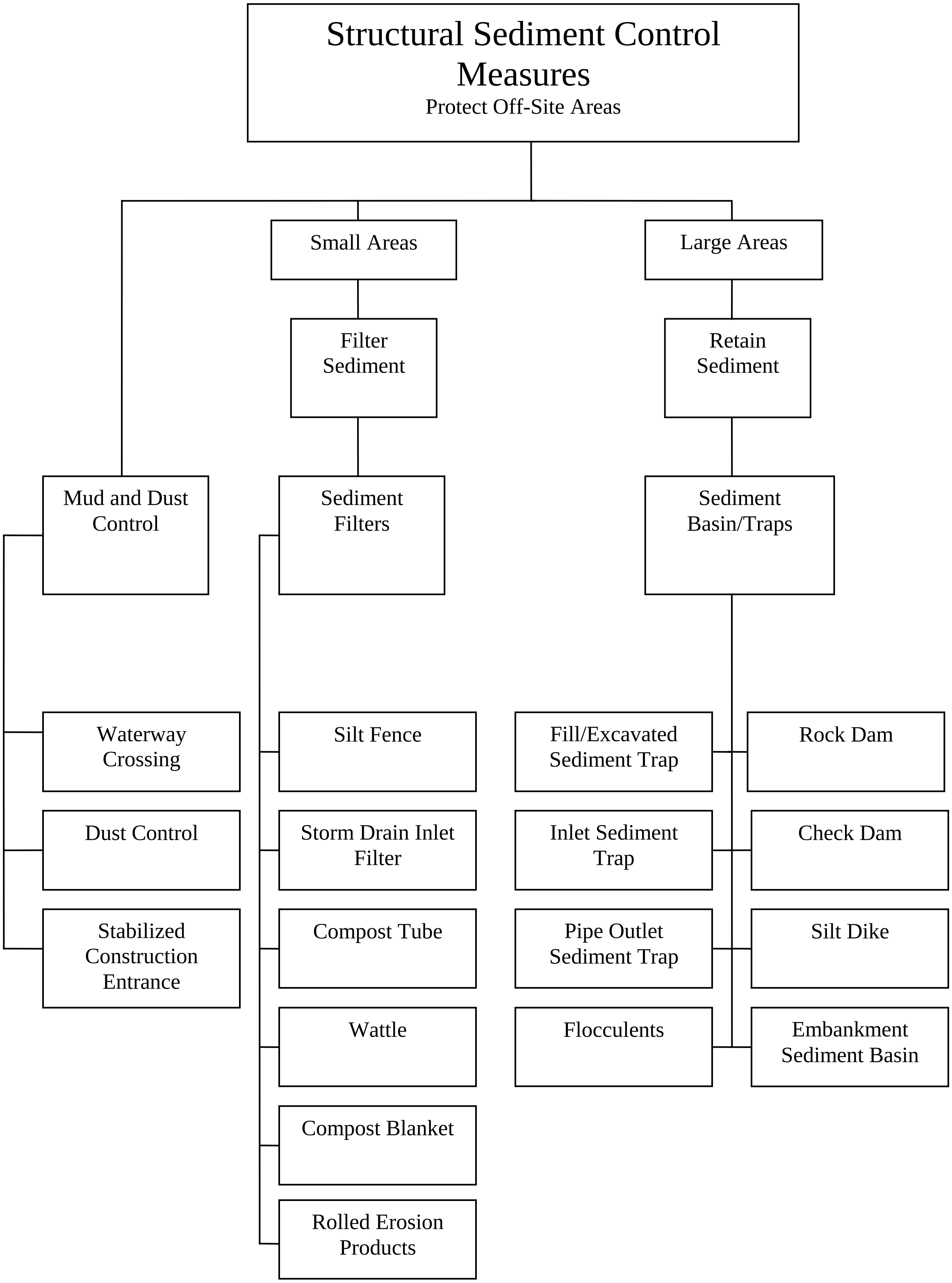

Figure 1.8. Structural sediment control measures

Table 1.6. Classification of vegetal cover in waterways based on degree of flow retardance by vegetation (Source: U.S. EPA 1976)

Retardance	Cover	Stand	Condition and height
A	Reed canarygrass	Excellent	Tall (average 36 in.)
	Kentucky 31 in. tall fescue	Excellent	Tall (average 36 in.)
B	Reed canarygrass	Good	Mowed (average 12 to 15 in.)
	Kentucky 31 in. tall fescue	Good	Unmowed (average 18 in.)
	Red Fescue	Good	Unmowed (average 16 in.)
	Kentucky bluegrass	Good	Unmowed (average 16 in.)
	Redtop	Good	Average
C	Kentucky bluegrass	Good	Headed (6 to 12 in.)
	Red fescue	Good	Headed (6 to 12 in.)
	Redtop	Good	Headed (15 to 20 in.)
D	Red fescue	Good	Mowed (2 ½ in.)
	Kentucky bluegrass	Good	Mowed (2 to 5 in.)

Table 1.7. Grass establishment alternatives (Source: VSWCC 1980)

Establishment Technique	Conditions	Remarks
1. Seeding with straw mulching and tack coat	1. Slopes less than 10%–15% 2. Velocity less than 3 fps 3. Majority of drainage cannot be diverted away from channel during germination and establishment 4. Erosion-resistant soils	1. See permanent seeding requirements. When mulching, use 2 tons/acre small grain straw with an acceptable tacking agent.
2. Seeding with straw mulching and jute mesh or erosion netting	1. Slopes less than 10%–15% 2. Velocity less than 5 fps 3. Majority of drainage cannot be diverted away from channel during germination and establishment 4. Moderately erodible soil	2. In addition to the first technique, straw mulching should be secured with netting. If using jute mesh, use only 1 ton/acre small grain straw, evenly distributed. If using a light plastic or paper erosion netting, 1 1/2 to 2 tons/acre of straw is appropriate. Excelsior blankets, used alone, are also acceptable mulching for waterways.
3. Sodding	1. Slopes greater than 10%–15% 2. Velocity between 5 and 6 fps 3. Majority of drainage cannot be diverted away from channel during germination 4. Highly erodible soil	3. See Sodding section for soil installation requirements.

Table 1.8. Maximum flow velocities (Source: USDA, SCS 1979b)

Channel lining	**Maximum velocity (fps)**	
Natural channels not completely clear	Water transporting	
Lined with vegetation	*Water*	*Colloidal silt*
(1) Sand and sandy loam	1.50	2.5
(2) Silt loam	2.00	3.0
(3) Sandy clay loam	2.00	3.5
(4) Clay loam	3.00	4.0
(5) Clay, fine gravel, and graded loam to gravel	3.75	5.0
(6) Graded silt to cobbles	4.00	5.5
(7) Shale, hardpan, and coarse gravels	6.00	6.0

Intercepting and Diverting Runoff

The water-handling structures discussed here are used to divert collected flow away from critical areas, and discharge collected runoff in suitable disposal areas, and intercept surface water runoff before it can cause damage. Structures used to collect and convey runoff are generally referred to as diversion structures. Diversion structures serve to do the following:

- Prevent surface runoff from higher undisturbed or stabilized areas from coming in contact with exposed soil surfaces
- Direct on-site water away from critical areas such as steep slopes, highly erodible soil, and landslide-prone areas
- Prevent sediment-laden runoff from an exposed slope from leaving the restoration site without first passing through a sediment-detention structure

Typical diversion structures are dikes, swales, ditches, or a dike and ditch combination. Diversion structures are ridges of compacted soil placed above, below, or around a disturbed area. Diversion swales are excavated temporary drainageways used above and below disturbed areas. Diversions are permanent or temporary drainageways constructed by digging a shallow ditch along a hillside and building a soil dike along the downhill edge of the ditch with the excavated soil.

Figure 1.9. Intercepting and diverting runoff (Source: Iowa DOT)

Figure 1.10. Diversion structure (Source: Virginia Department of Conservation & Recreation)

Figure 1.11. Diversion dike and swale combination (Source: ISU/CCEE)

Handling and Disposing of Concentrated Flows

In handling concentrated water flows, the primary goals are to control the flow's distance, decrease the gradient, and obstruct the flow. Flow distance may be controlled by lengthening drainageways. However, care must be taken to ensure that the resulting flow will not erode or overflow the channel. Flow gradient can be controlled through the placement of check dams and other flow control structures across the channel. Grade control structures also serve to obstruct flow within the channel and, as a result, slow its movement. Placement of the water-handling structure nearly parallel to the ground contour is a means of controlling the gradient and maximizing the flow distance. Again, care must be taken to ensure that the channel can carry the design flow without overtopping in critical areas, such as along erodible slopes.

Materials such as rock riprap placed in the channel will dissipate the energy of the flow. This will also reduce the ability of the concentrated flow to cause erosion. Energy dissipators should be placed below grade control structures and outfalls, and when necessary, along the outside of channel bends. Further information on the design of energy dissipators can be found in the Federal Highway Administration's Hydraulic Engineering Circular No. 14 (1975). See www.ntis.gov or call (703) 487-4650 for the publication.

Structures used to control concentrated flow include downdrain structures (rock chutes, flumes, and pipe slope drains) and waterways. Paved chutes (flumes) are channels extending from the top to the bottom of the slope and lined with non-erodible material such as bituminous concrete, portland cement, or grouted riprap. Rock chutes (flumes) are constructed in the same manner as paved chutes, but utilize natural stones or riprap materials. Pipe slope drains may be rigid pipe or flexible tubing connected to the prefabricated inlet section. These are considered temporary measures and extend from the top to the bottom of a slope.

Waterways are stabilized channels designed to handle the anticipated flow rate safely. Channel linings vary according to flow rates. Grade control structures and energy dissipators are also used to stabilize the channel for high-velocity water flow. See Tables 1.9 and 1.10.

Each water control structure must have a stable outlet. The outlet may be a natural drainageway, vegetated area, or other stable watercourse. In all cases, the outlet must convey the water without incurring erosion. Disposal of small flows in upland areas can be performed by using a level spreader. The structure is a well-stabilized outlet constructed at zero percent grade (along the outlet lip) that converts concentrated flow into less erosive sheet flow. The flow is discharged onto a vegetated slope in an area where the water will not be reconcentrated immediately below the structure.

Impoundment structures may also be used to control runoff by trapping sediment from the site and reducing downstream channel erosion and flooding problems. Trapping sediment is their primary function. However, when increased runoff is expected, off-site erosion and flooding potential should also be given careful consideration in the design and construction of water detention or retention structures. Impoundment structures such as sediment basins detain runoff and release it at a controlled rate. Thus, the ability of the inflowing water to carry sediment is reduced.

Table 1.9. Waterway linings in order of increasing flow velocity and handling capacity

Type	Remarks	Maintenance
Grass	• Need to divert water to establish vegetation • Lime, fertilize, seed, and mulch • Methods of keeping seeds and seedings on steep slopes (using cloth, latex spray, chemical tacks, etc.) • Cut mulching at 90^{o} to line-of-flow with rolling cultipacker	• Fertilize • Mow at height of 4–6 in. at least two times per year to prevent thatching of grass (Do not mow unless waterway will support equipment. Waterlogged soils in spring should be avoided.) • Rotor mower preferable to sickle bar mower
Channel liner	• Used for channels with occasional water flow that cannot be diverted • Erosion checks of fiberglass: 50 ft apart on sandy soils, 100 ft apart on heavier soils, and at gradient changes • Erosion checks must be flush with surface • Paper netting at sites with little flow • Installation by experienced persons only	• Routine inspection and replacement if necessary
Low-flow channel	• Riprapped subgraded ditch for constant flow (spring, seepage, etc.) • Grass on waterway sides • Jute or Enkamat liner	• Replace missing or damaged stone areas to original protection levels
Riprap	• Uses filter cloth for soils with poor structure or seepage areas with settling to keep uniform gradient of stone • Used when either low-flow channel or entire channel is riprapped	• Remove bridges or obstructions created by foreign objects to avoid ponding • Check for loose stones from frost heave in spring
Mattress (Maccaferri)	• Use when riprap is being carried away by flow • Flexible for lining channel • Use filter cloth underneath mattresses • Gabions and weirs used for de-energizing • Recommended in place of riprap where removal of stones by public is potential problem • Plastic-treated mattress needed where water contains salt or caustic materials	• Requires least maintenance and has longest life of all linings • Soil will eventually cover mattress and waterway will revegetate
Concrete	• Monolithic reinforced • Energy dissipators needed • Not suitable for acid flow • Not recommended for critical areas • Expensive, last resort	• Check for water underneath channel • Check for voids under and around channel • Watch for undermining from seepage underneath waterway

Table 1.10. Maximum permissible design velocities for stable grass-lined channels (Source: USDA, SCS 1975)

Cover	Range of channel gradient, %	Permissible velocity, fps
1. Bermudagrass	0 to 5.0	6
Reed canarygrass		5
Tall fescue		
Kentucky bluegrass		
Grass legume mixture		4
Red fescue		2.5
Redtop		
Sericea lespedeza		
Annual lespedeza		
Small grain (rye, oats, barley, millet)		
Ryegrass		
2. Bermudagrass	5.0 to 10.00	5
Reed canarygrass		4
Kentucky 31 in. tall fescue		
Kentucky bluegrass		
Grass legume mixture		3
3. Bermudagrass	Over 10.0	4
Kentucky bluegrass		3
Reed canary grass		
Tall fescue		

Outlets

Each diversion must have a stable outlet constructed and stabilized prior to the operation of the diversion. The outlet may be a natural or constructed waterway, a stabilized open channel, a grade stabilization structure, a sediment trap or basin, a level spreader, or any of a variety of down-drain structures. In all cases, the diversion must discharge into the outlet in such a manner as not to cause erosion.

Stabilization

Once construction is completed, stabilization of the soil surface must be accomplished as soon as possible. Vegetative covers should be established as soon as possible. If anticipated velocities are greater than six fps, a non-vegetative material such as riprap lining should be considered.

Maintenance

Diversion structures should be inspected approximately every two weeks and after every substantial storm event. Repairs should be made whenever necessary. Sediment removal from the ditch line should be made when necessary to maintain the discharge capacity of the structure. A vegetative cover that has failed to establish or has otherwise failed should be promptly reseeded and mulched (see Table 1.10).

Table 1.11. Permissible velocities for earth-lined channels (Source: Soil & Water Conservation Engineering, Schwab et al., & American Society of Civil Engineers)

Soil types	Permissible velocity, fps
Fine sand (non-colloidal)	2.5
Sandy loam (non-colloidal)	2.5
Silt loam (non-colloidal)	3.0
Alluvial silts (non-colloidal)	3.5
Ordinary firm loam	3.5
Fine gravel	5.0
Stiff clay (very colloidal)	5.0
Graded, loam to cobbles (non-colloidal)	5.0
Alluvial silts (colloidal)	5.0
Cobbles and shingles	5.5
Graded, silt to cobbles (colloidal)	5.5
Coarse gravel (non-colloidal)	6.0
Shales and hard pans	6.0

Erosion Control Measures

In selecting a control measure, a number of items need to be reviewed and evaluated. More than one measure may work effectively, or a measure may be modified to fit a special situation. Each of the control measures will contain the following information: name of control measure, problem identification, design purpose, associated practices, design life, and estimated cost. From this information, the designer can select the control measure that is the most economical, practical, efficient, and adaptable to the site.

Erosion control measures are divided into three categories:

1. Vegetation and soil stabilization erosion control measures
2. Structural erosion control measures
3. Special condition erosion control measures

Individual measures are described in Chapters 2–4.